Copy No. _____

Defence Research and Development Canada   Recherche et développement pour la défense Canada

DEFENCE R&D DÉFENSE

Evaluation of Visual Alerts in the Maritime Domain

Behavioural Research Study

Shelley Roberts and Tara Foster-Hunt
CAE Professional Services

CAE Professional Services
1145 Innovation Drive
Kanata, Ontario K2K 3G7

Project Manager: Joseph Armstrong, 613-247-0342 x203
Contract Number: W7707-07-8043
Contract Scientific Authority: Jacquelyn M. Crebolder, 902-426-3100 x296

In conducting the research described in this report, the investigators adhered to the policies and procedures set out in the Tri-Council Policy Statement: Ethical conduct for research involving humans, National Council on Ethics in Human Research, Ottawa, 1998 as issued jointly by the Canadian Institutes of Health Research, the Natural Sciences and Engineering Research Council of Canada and the Social Sciences and Humanities Research Council of Canada.

Defence R&D Canada – Atlantic

Contract Report
DRDC Atlantic CR 2008-057
September 2008

Canada

This page intentionally left blank.

Evaluation of Visual Alerts in the Maritime Domain

Behavioural Research Study

Shelley Roberts
CAE Professional Services

Tara Foster-Hunt
CAE Professional Services

CAE Professional Services
1145 Innovation Dr.
Kanata, Ontario
K2K 3G7

Project Manager: Joseph Armstrong, 613-247-0342 x203

Contract number: W7707-07-8043

Contract Scientific Authority: Jacquelyn Crebolder, 902-426-3100 x296

In conducting the research described in this report, the investigators adhered to the policies and procedures set out in the Tri-Council Policy Statement: Ethical conduct for research involving humans, National Council on Ethics in Human Research, Ottawa, 1998 as issued jointly by the Canadian Institutes of Health Research, the Natural Sciences and Engineering Research Council of Canada and the Social Sciences and Humanities Research Council of Canada.

Defence R&D Canada – Atlantic

Contract Report

DRDC Atlantic CR 2008-057

September 2008

Author

Shelley Roberts and Tara Foster-Hunt

Approved by

Original signed by Jacquelyn Crebolder

Jacquelyn Crebolder

Approved for release by

Original signed by James L. Kennedy

James L. Kennedy

DRP Chair

Abstract

The current study was designed to explore alternative methods of enhancing the manner in which operators are alerted in the Halifax Class Frigate operations room. As the auditory modality is overloaded in the current alerting system, one method of potentially reducing perceptual overload is to replace auditory alerts with alerts presented in the visual domain. The purpose of the current study was to investigate how a high intensity task spread across multiple displays impacts the detection of visual alerts. The experimental design included two types of alerts (flashing border/status bar) presented independently on the left, right, or centre display or on all three displays. Participants were required to complete two tasks: 1. Classify and report contacts appearing on the centre display as hostile or neutral, and 2. Detect and respond to visual alerts. Reaction time to alerts and accuracy of the identification of alerts and contacts were examined. In general, reaction time to status bar alerts was faster than to border alerts, although no significant difference was observed when the alerts appeared on the left display. Responding to the status bar alert when it was presented on all three displays at once compared to all other alert configurations was found to be fastest. No significant difference in accuracy was found. Results in this study suggest that the type and location of visual alerts has a significant impact on reaction time but no impact on accuracy. Further investigation of the interaction between auditory and visual alerts and their impact on high intensity tasks is highly recommended for future work.

Résumé

La présente étude a été élaborée pour explorer des méthodes de rechange permettant d’améliorer la façon avec laquelle les opérateurs sont alertés dans le PC opérations des frégates de classe Halifax. Comme le mode audible est surchargé dans le système d’alerte actuel, une des méthodes permettant la diminution possible de la surcharge au niveau de la perception consiste à remplacer les alertes sonores par des alertes visuelles. Le but de la présente étude est de faire enquête sur la façon dont une tâche à haute intensité répartie sur plusieurs écrans d’affichage a un impact sur la détection d’alertes visuelles. La conception expérimentale comprenait deux types d’alertes (limite clignotante/barre d’état) présentés indépendamment sur l’écran de gauche, de droite ou du centre, ou sur les trois écrans. Les participants devaient effectuer deux tâches : 1. classer et communiquer les contacts apparaissant sur l’écran du centre comme étant hostiles ou neutres et 2. détecter les alertes visuelles et réagir à celles-ci. Le temps de réaction aux alertes et la précision de l’identification des alertes et des contacts ont été examinés. En général, le temps de réaction aux alertes de barre d’état a été plus rapide que le temps de réaction aux limites clignotantes bien qu’aucune différence importante n’a été observée lorsque les alertes se sont affichées sur l’écran de gauche. La réponse à l’alerte de la barre d’état lorsque celle-ci s’est affichée sur les trois écrans en même s’est avérée plus rapide que toutes les autres configurations d’alertes. Aucune différence importante en matière de précision n’a été remarquée. Les résultats de la présente étude suggèrent que le type et l’emplacement des alertes visuelles ont un impact important sur le temps de réaction, mais qu’ils n’en ont aucun sur la précision. Il est fortement recommandé d’effectuer dorénavant une enquête plus approfondie sur l’interaction entre les alertes sonores et les alertes visuelles et sur leur impact sur les tâches de haute intensité.

Executive summary

Introduction

The Halifax Class Frigate operations room is a demanding, high intensity environment, manned by approximately twenty Navy personnel, most of whom are sensor operators. Automated systems to assist operators are a necessity in this busy environment and an automated auditory alerting system is currently in place in the operations room to warn of impending system and tactical states. However, due to the persistent and uninformative nature of the alerts operators tend to ignore them or turn off the alerting system as part of the watch changeover procedure. The current study is designed to explore methods of enhancing the way operators are alerted in complex high intensity environments like frigate operations rooms.

When the auditory modality is overloaded one way of alleviating the problem is to replace some of the auditory alerts with visual ones. Visual alerts must obviously be located where they can be seen, but equally important is the requirement that alert symbology or text does not obscure other task-related information appearing on the display. However, when operators are concentrating on a task, particularly during a period of high workload, alerting information may be missed if attention is focused on another area of the display. Hence, a challenge to providing visual alerts is to ensure that the symbology is salient enough to be noticed while the operator is otherwise engaged.

The symbology used for this study was designed based on subject matter expert suggestions that flashing borders could surround the operator's screen as an alternative to auditory alerts. Another common visual alerting technique is a status bar located in the perimeter of the display. Both the flashing border and status bar alerting techniques were investigated in this study. Additionally, because the operator's workstation in a modernized configuration of the operations room is expected to consist of three displays, whether to present visual alerts on one or all of the displays was investigated.

Results

Results indicate that regardless of the location of the alerts, participants responded faster to the status bar compared to the flashing border, with the quickest response time coming from the status bar alert when presented across all three screens at one time. One condition where this was not the case was when alerts were presented on the left screen. The alert types and locations had no impact on participants' accuracy in identifying the hostile and neutral contacts suggesting that, although the response times were affected by alert type and location, participants were able to attend and respond to all alerts successfully regardless of type or location.

Significance

Results from this study will provide insight into whether visual alerts are a viable Alternative in complex high intensity environments like the Halifax Class Frigate

operations room. The findings provide an initial step in determining what types of alerting techniques might be most suitable.

Future Plans

Future work will continue to investigate properties of visual alerts with the aim of providing operators with an informed tool for alerting to system and operational states. Research issues will include the following: location of the status bar on the display; information content, static versus dynamic status bar; effects of display clutter on visual alerts, and operator performance. The work will also collaborate with research in auditory alerting at DRDC Toronto with the aim of combining visual and auditory stimuli into an integrated alerting system.

Roberts, S. & Foster-Hunt, T. 2008. Evaluating Visual Alerts in the Maritime Domain. DRDC Atlantic CR 2008-057.

Sommaire

Le PC opérations des frégates de classe Halifax est un environnement très intense et exigeant où travaillent environ vingt employés de la Marine, dont la plupart sont des opérateurs de capteurs. Les systèmes automatisés servant à aider les opérateurs sont une nécessité dans cet environnement occupé; un système d'alarme sonore automatisé est présentement en place dans le PC opérations pour signaler les états tactiques et de système en attente. Cependant, à cause de la nature persistante et non informative des alertes, les opérateurs ont tendance à les ignorer ou à mettre hors-service le système d'alarme lors du changement de quart de travail. La présente étude vise à explorer des manières d'améliorer la façon avec laquelle les opérateurs sont alertés dans des environnements à haute intensité complexes comme le PC opérations des frégates.

Lorsque le mode audible est surchargé, une des façons d'amoindrir le problème est de remplacer certaines des alertes sonores par des alertes visuelles. Les alertes visuelles doivent évidemment être situées à un endroit où on peut les voir, mais il est aussi important que le texte ou les symboles d'alerte ne cachent pas d'autres informations de travail apparaissant à l'écran. Cependant, lorsque les opérateurs se concentrent sur une tâche, particulièrement pendant une période où la charge de travail est grande, ils pourraient ne pas remarquer qu'il y a une alerte s'ils se concentrent sur une autre zone de l'écran. Donc, l'un des défis des alertes visuelles est de s'assurer que les symboles utilisés sont assez frappants pour que l'opérateur les remarque pendant qu'il fait autre chose.

Les symboles utilisés pour cette étude ont été conçus à l'aide de la suggestion d'experts en la matière à l'effet que des bordures clignotantes pourraient entourer l'écran de l'opérateur et, ainsi, constituer une solution de rechange aux alertes sonores. Une autre technique d'alarme visuelle courante est une barre d'état située autour de l'écran. Les deux techniques d'alerte que sont la bordure clignotante et la barre d'état ont été analysées lors de la présente étude. De plus, à cause du fait que l'on s'attend à ce que le poste de travail de l'opérateur dans une configuration modernisée du PC opérations consiste en trois écrans, on a cherché à savoir s'il était préférable de présenter des alertes visuelles sur un écran ou sur tous les écrans.

Résultats

Les résultats indiquent que, peu importe l'emplacement des alarmes, les participants ont réagi plus rapidement à la barre d'état qu'à la bordure clignotante; les résultats indiquent aussi que le temps de réponse le plus court a été obtenu avec la barre d'état affichée sur les trois écrans en même temps. Un des exemples où cela n'a pas été le cas est lorsque les alertes étaient affichées sur l'écran de gauche. Les emplacements des alertes et les types d'alertes n'ont pas eu d'impact sur la précision des participants lors de l'identification des contacts hostiles et neutres; cela suggère que, bien que les temps de réponse aient été affectés par les emplacements et les types d'alertes, les participants ont été en mesure de répondre à toutes les alertes avec succès, peu importe leur type ou leur emplacement.

Portée

Les résultats de la présente étude permettront de déterminer si les alertes visuelles constituent une solution de rechange viable dans les environnements complexes à haute intensité comme le PC opérations des frégates de classe Halifax. Les conclusions sont un premier pas vers la détermination des types de techniques d'alerte qui pourraient être les plus adéquats.

Recherches futures

Les travaux futurs continueront à porter sur les propriétés des alertes visuelles dans le but de fournir aux opérateurs un outil d'alerte spécialisé pour les états opérationnels et de système. Les questions de recherche comprendront ce qui suit : emplacement de la barre d'état à l'écran; contenu en information, barre d'état statique versus barre d'état dynamique; effets d'accumulation à l'écran sur les alertes visuelles et rendement de l'opérateur. Les travaux contribueront aussi à la recherche en matière d'alertes audibles à RDDC Toronto dans le but de combiner les stimuli visuels et audibles en un système d'alerte intégré.

Table of contents

List of figures

List of tables

This page intentionally left blank.

1. Background

1.1 Domain

The Halifax Class Frigate operations room is manned by approximately twenty personnel who monitor and manage a variety of sensors (electronic, visual, auditory) using command and control displays. The operations room is a demanding environment with periods of high stress and workload, during which critical decisions must be made quickly and accurately. Most of the sensor operators in the operations room use several displays concurrently and multi-tasking is all too familiar. Given such a busy environment automated systems that assist Halifax Class Frigate operators in performing their tasks are a necessity. Currently an automated alert system is set up to alert operators to system states, operational states, and situations in need of attention or action.

1.1.1 Problem

Recent discussions with navy personnel indicate that the standard procedure in the operations room of the Halifax Class Frigate is to switch off the alert system as soon as an operator comes on duty. There are a number of possibilities why the alert system is intentionally deactivated: the majority of alerts are auditory, burdening an already overtaxed modality; all operators receive all alerts, many are of no concern for an individual operator; alerts are not informative, they are single tone; there is no alert hierarchy; the presentation of auditory alerts is almost constant.

The current study is designed to explore methods of improving the way operators are alerted in complex environments where their attention is divided between multiple information sources. If the auditory modality is overloaded, as it is in the operations room, one way of alleviating the problem is to replace some of the auditory alerts with visual ones.

1.2 Potential Solutions

1.2.1 Alert Type

Auditory warnings are typically chosen over visual ones in order to attract the attention of operators that are under a high visual workload. Salvendy (1997) argues that auditory alerts may be superior to visual warnings as they are omni-directional and operators need not look at a particular location to be alerted. Unlike auditory alerts, visual alerts need to be presented where they can be seen and since an operator’s activity revolves around a computer-based workstation the most likely placement of an alert would be on one or all of the displays that the operator uses. However, there are three main challenges to presenting visual alerts on a display that is used for other visual tasks.

The first challenge encountered is selecting the symbology or text that constitutes the alert itself. It is imperative that the alert does not obstruct other task-related information on the display screen. Thus, a suitable location for visual alerts must be established whereby the symbol(s) or text is easily visible, in a form that is salient, without being an impediment to the current task. The most likely location is in the periphery of the work area; however attending to peripheral information has its own challenge.

The second challenge is that during periods of high workload an operator's concentration can be wholly absorbed in the task at hand. Consequently it is not unusual for critical information to be missed if his or her attention is focused on one area of a display and if information is not prominently displayed in that particular field of view. The phenomenon, where attention is so focused on one visual area that important information may be missed in another area, is sometimes referred to as attentional tunneling or attentional spotlight (Wickens, 2005). It is necessary to provide a stimulus for alerting purposes that is salient enough so that it will be noticed by an operator when he or she is engrossed in the task at hand and where his attention may not be focused on the alerting area of the display. This point is intensified when more than one display is used to perform a task.

The final challenge is the potential for the phenomenon of visual dominance occurring. Visual dominance refers to the tendency for visual stimuli to dominate awareness when other stimuli are presented simultaneously in non-visual modalities (Colavita & Weisberg, 1979; Cooper, 1998; Posner, Nissan & Klein, 1976). Interestingly when visual and auditory stimuli are presented separately, visual reaction time is typically slower than auditory reaction time. However, when visual and auditory stimuli are presented simultaneously, priority is given to the visual stimulus in terms of reaction time (Cooper, 1998).

Visual alerts may not only dominate attention when compared to other modalities, but are also found to be subjectively preferred. Donmez, Boyle and Lee (2006) conducted research on the modality of automated systems in automobile warnings designed to alert drivers to potential threats ahead, e.g. braking cars or sharp curves in the road. Differences between a visual alert consisting of a red static border (similar to the current flashing border used in the current study) and an auditory clicking noise on drivers' preference were investigated. Drivers were found to subjectively prefer and trust visual alerts when compared to auditory alerts.

It should be noted that although the current study investigates visual alerts only, readers should be aware of visual dominance prior to implementing a combination of alerts in these two modalities. This phenomenon will be discussed in further detail in the discussion section regarding future research.

1.2.2 Alert Location

It is anticipated that redesign of the operations room in the Halifax Class frigate will provide the operator with a workstation that consists of three displays positioned side by side. The centre display will be a tactical display, the one on the left is anticipated to be an information/status display, and the one on the right a communication (e.g., chat/email) display. In recent interviews with Halifax Class Frigate personnel, subject matter experts suggested that flashing borders around the edges of the display window might be a suitable visual alert. Another common visual alerting technique used in other environments is a status bar, located in the perimeter of the display, which can contain information about the status of the system or the nature of the alert. As an example, battery status of electronic equipment is often displayed in a status bar format. The flashing border and status bar are the two alerting techniques to be investigated in this study. The status bar used will be a vertical coloured strip, about 2 cm wide, located on the display(s) (see Figure 5). The bar will contain no information but its presence will indicate an alert in need of a response (see Figure 6).

Since the workstation is expected to accommodate three displays an additional question that arises is whether or not visual alerts should be presented on one or all of the displays. The operator will frequently be involved in a task that uses all three displays so presenting the alert on all displays may reduce the chance of it being missed. However, particularly with respect to flashing symbology, alerts on all three displays could become distracting especially if directed to several operators at the same time. Therefore the current study will establish empirically whether or not there is a significant benefit to displaying alerts on all displays as opposed to one.

1.3 Objectives

This experiment was designed to investigate how different types of visual alerts might impact an operator's performance, especially when the operator's task requires monitoring more than one display while multitasking. The experimental design included two types of alerts (flashing border/status bar) and the location of these alerts consisted of presentation on the left, middle, right or all three displays at once. Reaction times to each alert type and location as well as accuracy in identifying contacts were recorded.

1.4 Requirements

The requirements, stipulated by DRDC Atlantic, were bound by two phases:

1.4.1 Phase I - Pilot Study

The pilot study was used to gain an overall understanding of the objective of the experiment as included the following tasks:

1. Format and content of the data output files and the conversion procedure to SPSS;
2. Test and finalize the experimental script, data output, and experimental procedure and modify if necessary;
3. With assistance from the Project Authority locate a participant pool and schedule participants;
4. Conduct the pilot study – administer each participant through the experiment;
5. Record any issues in experimental procedure or experimental script and discuss appropriate measures to resolve with the SA;
6. Collect and format the data for analysis;

7. In consultation with the Project Authority analyze the data using SPSS for Windows;
8. Through discussion with the Project Authority provide an interpretation of the results;
9. Modify the experimental procedure and experimental script if necessary; and
10. Retest the software if necessary.

1.4.2 Phase II - Primary Study

The primary study included the following tasks:

1. Locate and schedule participants for the primary experiment;
2. Conduct the primary experiment;
3. Collect and format the data output files for analysis;
4. In consultation with the Project Authority analyze the data using SPSS for Windows;
5. Through discussion with the Project Authority provide an interpretation of the results.

1.4.3 Report

The experimental procedure, method of data collection and analysis, results, interpretation of the analysis, and any issues or limitations observed throughout the pilot study and primary experiment are included in this report.

2. Methods

2.1 Participants

Twenty-four participants (15 males, 9 females) were recruited for the study which took approximately 45 minutes to complete. Participants were reimbursed $15.68, according to DRDC Toronto stress level guidelines (Pigeau, R., 1992), with an additional transportation reimbursement for volunteers coming from outside DRDC Atlantic of $15. Participants' backgrounds consisted of DRDC Atlantic civilian and military employees, members of the Canadian Forces, and undergraduate students from local universities in Halifax, Nova Scotia (Dalhousie University; Saint Mary's University). A recruitment poster (Annex A) was distributed by email and/or posted at respective establishments. Participants mean age was 41.25 (SD=12.45) with a range of 22 to 70 years, all reported normal or corrected-to-normal vision, and 79% were right-handed. Five of the 24 participants indicated that they had previous experience with multiple displays while multitasking. This study was conducted in the performance laboratory at DRDC Atlantic.

2.2 Apparatus

Two workstations were constructed, each consisting of three 20.1" liquid crystal display (LCD) computer monitors running Windows XP Professional (Service Pack 2), with a single keyboard and mouse input device. The displays were configured so that the centre monitor depicted a tactical display in the centre, a status display on the left, and a reporting display on the right (see Figure 1). The experimental program was scripted using E-Prime experimental psychology software. Rooms with normal temperature and lighting dimmed to simulate the operations room environment and to avoid glare on the screens were used to conduct the experiment.

Figure 1. Workstation configuration

2.3 Stimuli

The stimuli in this experiment differed across the three displays:

1. Tactical (middle) display - moving contacts in the form of triangle symbols appearing in the periphery of the tactical display moved towards the operator's ownship which was represented by a light grey circle in the middle of the display (See Figure 2).

Figure 2. Screen capture of the Tactical (middle) display.

2. Status (left) display – provides information on a selected contact in the form of text. Information included: speed (slow/fast), size (small/large), and weapons onboard (yes/no).

Figure 3. Screen capture of the Status (left) display.

3. Reporting (right) display- includes a window for typing in the contact category which was either the letters "asd" for hostile, or "qwe" for neutral. These letters were chosen as the input for reporting contact type for a few reasons. During the pilot study it was observed that participants were having difficulty typing out the words "neutral" and "hostile" in full in the time allocated, and the spelling mistakes being made would have interfered with the findings given the way the data was collected.

Figure 4. Screen capture of the Reporting (right) display.

2.4 Task

Participants were required to complete two main tasks, respond to visual alerts and identify contacts as hostile or neutral.

2.4.1 Alerts

Throughout the categorization task two alert types, flashing border (See Figure 5) and status bar (See Figure 6), were presented intermittently on one (right, middle or left) or all 3 displays, depending on the experimental condition.

Figure 5. Screen capture of the Flashing border alert displayed on all three screens.

Figure 6. Screen capture of the Status bar alert displayed on all three screens.

Participants were required to attend to the alert as quickly as possible by hitting the spacebar on the keyboard. If an alert was missed it would cancel out after 4 seconds and be as recorded as missed.

2.4.2 Contacts

Contacts, symbolized as green rectangles, originated in the periphery of the tactical display and moved toward the ownship, located at the centre of the display (See Figure 2). Participants were warned that keeping contacts from the ownship is critical, because if a contact crosses over into the grey circle the ownship will be destroyed, the result of which is discussed below.

Participants were instructed to place the mouse cursor over a contact on the tactical display to obtain information related to the contact's attributes which would then appear on the status display (see Figure 3). Three attributes were assigned to each contact (speed, weapons on board, and size). Certain attribute values represented hostile characteristics while others represented neutral.

Table 1. Possible contact attributes presented on the Status display.

	Categorized as Hostile	**Categorized as Neutral**
Size	Small	Large
Speed	Fast	Slow
Weapons	Yes	No

Participants were required to derive from the attribute information whether a contact was neutral or hostile: 2 or more hostile values = hostile; 2 or more neutral values = neutral. Once a decision had been made the choice was reported on the reporting display to the right of the tactical display as “asd” for “hostile” and “qwe” for “neutral”. The report was immediately verified by the system as correct or incorrect and participants were given immediate feedback on the reporting display. If the contact was correctly identified it would disappear off the screen and a new contact would enter from the periphery of the tactical display, thus alleviating the number of contacts on the screen that were located close to the ownship. If a contact was incorrectly identified the contact would continue to move towards the ownship until it was correctly identified.

If a contact (hostile or neutral) met with the ownship, represented by a light grey circle in the middle of the tactile display, the program was immediately halted, an audio file of a “kaboom” noise was played, and a picture of a ship being destroyed was displayed on the middle screen for 5 seconds (see Figure 7). The session then starts over with the contacts, originating in the periphery of the tactical display and moving towards the ownship again.

Figure 7. Screen capture ship being destroyed resulting from the ownship being met by a contact.

2.5 Procedure

After completing the consent form (Annex B) a general practice session was conducted to familiarize participants with the displays, functions, and tasks. This was a multitasking experiment that required participants to divide their attention to two different aspects of an operator's task, responding to alerts and identifying targets. Therefore a practice session was critical in order to ensure participants familiarity with the tasks and procedure.

The practice session began with a set of instructions that can be found in, and was followed by two blocks of the experiment. Each block consisted of one type of alert (either flashing border or status bar) displayed 16 times across 4 locations (4 alerts on each of the right, middle, left and all three displays). The order in which the alert appeared on the 4 locations was randomly selected. The practice session consisted of two blocks, one block of the flashing border alert type and one block of the status bar alert type, each lasting approximately 3 minutes.

The main experiment consisted of eight blocks (lasting approximately 3 minutes each). The experimental blocks varied with respect to the type of alert displayed (flashing border/status bar), and the location on which the alert is presented (right, left, middle, and all 3 screens) making a 2 (alert type) x 4 (location) within-subjects design. Alert type was blocked and randomly presented to each participant and location of the alert was counterbalanced within each block. Therefore each participant received 4 blocks of each alert type (4 status bar and 4 flashing border) with the order of the eight blocks randomized for each participant. Participants were debriefed at the end of the experiment.

2.6 Performance measures

Performance measures include accuracy and response time as follows:

2.6.1.1 Time from onset of the alert to response to the alert

Data was collected for each response participants made by pressing the space bar, indicating that they attended to the status bar and flashing border alerts. Alert data collected for use in the analysis was alert onset (actual time the alert appears on the display(s) in milliseconds), and alert response time (computer logged time of space bar pressed). Participant reaction time was calculated as the alert onset time minus the alert response time. Shorter reaction times indicated better performance.

2.6.1.2 Number of alerts responded to

Frequency counts were collected and analyzed for alert Hit data for each participant across all trials and blocks. Higher numbers of hits to alerts indicated a higher accuracy level and better performance. The experimental program collected data for each participant for alert onset, offset and participant reaction time. For responses to alert during presentation an alert accuracy code of 1 was assigned.

2.6.1.3 Number of alerts missed

Frequency counts were collected and analyzed for alert miss data for each participant across all trials and blocks. Lower counts of misses indicated a higher level of accuracy and better performance. Participant responses prior to an alert being presented (false alert) and responses after an alert (misses) were coded as a 2 by the experimental program. If a participant did not respond to an alert at all, a zero was assigned. For analysis purposes entries coded as 0’s and 2’s were both counted as misses.

2.6.1.4 Number of destroyed ownship

Frequency counts were collected for the number of destroyed ownship during each experimental session for each participant. Lower numbers of destroyed ownship indicated better performance.

2.6.1.5 Identification of contacts

The number of correct and incorrect identifications of approaching contacts was collected and analysed. The experimental program collected the contact type (hostile or neutral) that was currently selected by the participant, the participants’ response. Accuracy was coded as a 1 for correct and a 2 for incorrect. Counts were conducted on the data with higher numbers of correct identifications indicating better performance.

3. Results

The following section reviews results obtained during the primary study.

3.1 Preliminary Analysis

The data was analyzed for participant reaction to alerts and their ability to identify contacts. Reaction time and number of alerts responded to (hits/misses) were analyzed to investigate the impact of the two visual alert techniques (flashing border /status bar), across blocks by location (right, middle, left and all three). Prior to the main data analyses the data was checked for violations of statistical assumptions such as outliers, missing data points and normality.

3.1.1 Missing Data

Data for one participant was deemed incomplete and not usable due to software failure as it did not record the locations in which the alerts were presented. The data from this file was not included in any subsequent analyses, leaving 24 data files for analysis. All other pariticpant files were examined and found to be complete.

3.1.2 Outliers

Two outliers were identified and filtered from the data set thereby reducing the number of cases from N=24 to N=22 for all subsequent analyses. Participants whose majority of studentized residuals of their dependent variables was greater than 2.5 were considered outliers.

3.2 Alerts

The following section presents the analyses of alert data collected during the primary study.

3.2.1 Alert Response Accuracy

Data was collected for each response participants made by pressing the space bar, indicating that they attended to the status bar and flashing border alerts. Participant's response to alert type at each location was also analyzed to asses whether attention to either type of alert is dependent on the display location on which it is presented. Data was collected as a "Hit" if the space bar was pressed while the alert was on the display or as a "Miss" if the space bar was not pressed while the alert was presented.

The Shapiro-Wilkes test of normality indicated that the hit data for both types of visual alerts (status bar/flashing border) violated the statistical assumption of normality. Statistics for normality of sampling distribution indicated the overall hit data for border alerts collapsed across location was significantly negatively skewed. Normality assessment also indicated that the miss data violated the statistical assumption of normality. The miss data for both alert types and all four locations had statistically significant leptukurtic distributions. Based on discussions with the SA a root-arcsine transformation was performed on the hit and miss data.

To normalize the data the root-arcsine transformation was calculated in three steps: 1. calculating the proportion of the hits and misses to total number of alerts presented for each alert type and location, 2. taking the square root of the proportions, and finally 3. taking the arc sine of each square-rooted proportion. Unfortunately this transformation did not result in a change in the skewed distribution.

In spite of non-normality of hit and miss data, a 2 (alert type) x 4 (location) repeated measures ANOVA was performed on the root-arcsine transformed data in order to investigate the effects alert type and location had on participants' accuracy. The RM-ANOVA revealed no significant differences for effect of alert type and location on either hits or misses. For example, approximately 15.5 alerts were presented within each block and on average 15.35 of those were responded to. Therefore it can be argued that transformations may not work on normalizing the hit and miss data due to the nature of this measurement as it resulted in a ceiling effect (refer to the raw means for the total number of alerts presented and the number of hits and misses for each alert type provided below in Tables 2, Table 3, and Table 4 respectively.

It should be noted that although the experiment was designed to present 16 alerts within each of the 8 blocks (4 alerts at each location), this was not always the case. The mean number of alerts per condition can be round found in Table 2. This problem is likely related to a timing error in the software and will need further investigation before future work can be conducted.

Table 2. Mean Number of Status Bar and Border Alerts presented by Location

Location/Alert Type	Mean # of Alerts Presented Across All Blocks	Std. Deviation	N
Left Status Bar	15.75	0.68	24
Middle Status Bar	15.75	0.44	24
Right Status Bar	15.42	0.78	24
All Status Bar	15.38	0.71	24
Left Border	15.46	0.98	24
Middle Border	15.50	0.88	24
Right Border	15.17	1.09	24
All Border	15.33	0.64	24

Table 3. Mean Misses by Alert Type and Location

Location/Alert Type	Mean # of Misses Collapsed Across Blocks	Std. Deviation	N
Left Status Bar	0.08	0.28	24
Left Border	0.08	0.41	24
Middle Status Bar	0.00	0.00	24
Middle Border	0.08	0.41	24
Right Status Bar	0.00	0.00	24
Right Border	0.13	0.45	24
All Status Bar	0.04	0.20	24
All Border	0.00	0.00	24

Table 4. Mean Hits by Alert Type and Location

Location/Alert Type	Mean # of Hits Collapsed Across Blocks	Std. Deviation	N
Left Status Bar	15.63	0.77	24
Mid Status Bar	15.50	0.93	24
Right Status Bar	15.21	0.83	24
All Status Bar	15.42	0.65	24
Left Border	15.21	0.98	24
Mid Border	15.54	0.72	24
Right Border	15.00	1.10	24
All Border	15.25	1.11	24

3.3 Reaction Time (RT) Data Results

Reaction time data was averaged across all 8 blocks for alert type by location and tested for normality. Both status bar and flashing border reaction time distributions were found to have a significant positive skew. Reaction time, as a measure of human behaviour, is known to have a statistical characteristic of positive skewness. To deal with this violation of normality a log(10) transformation was applied to all reaction time data used throughout the following analyses.

To determine the effects that alert type and location had on participant reaction time a 2 (alert type) x 4 (location) repeated measures ANOVA was performed. A shorter reaction time indicates better performance. The RM-ANOVA revealed a significant interaction of alert type by location, $F(1, 21) = 6.71$, $p < .05$, $MSE = .006$, $\eta_\rho^2 = .24$, indicating the effect of alert type on participant reaction time was influenced by the location the alert appeared (see Figure 8).

A significant main effect of alert type, $F(1,21) = 36.42$, $p < .01$, $MSE = .006$, $\eta_\rho^2 = .63$, was found. This indicates that participants were quicker in responding to status bar alerts (marginal mean = 2.919 ln, standard error = 2.2%) compared to flashing border alerts (marginal mean = 2.990 ln, standard error = 1.6%) when collapsed across location (see Figure 9). Further, a significant main effect of location, $F(1, 21) = 9.58$, $p < .01$, MSE = .007, $\eta_\rho^2 = .31$,was found indicating that response times were faster to alerts presented on all screens (marginal mean = 2.93 ln, standard error = 1.6%) when collapsed across alert type.

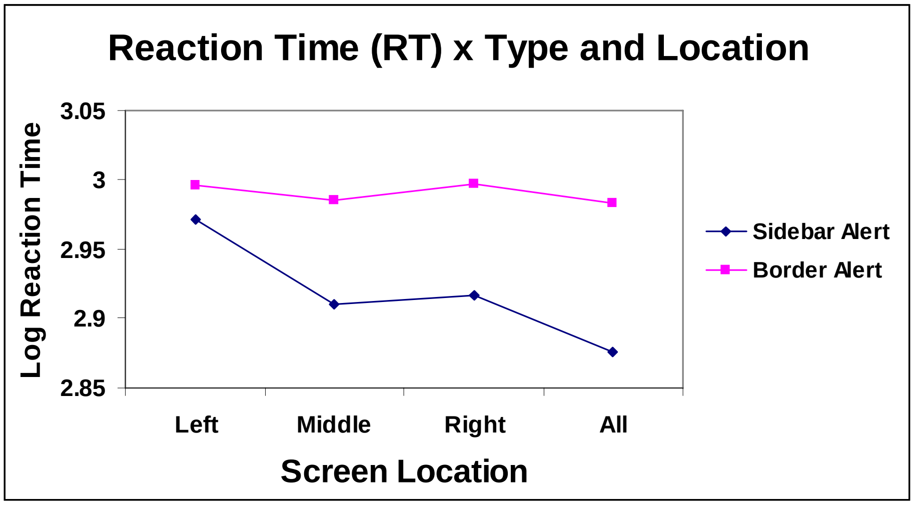

Figure 8. Log Reaction Time x Type and Location

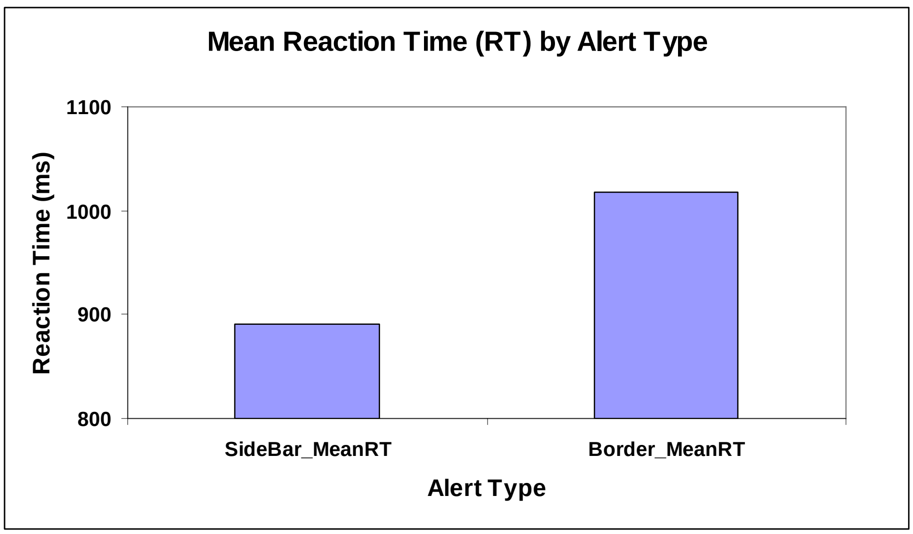

Figure 9. Overall Mean RT by Alert Type

Seven post hoc pair-wise comparisons using Bonferroni correction were conducted resulting in a critical p-value of 0.35. A priori pair-wise comparisons indicated that reaction times were significantly faster for status bar alerts presented on all screens at once when compared to all other status bar and border conditions (see Table 5 for a summary of t-test values and means) except when the status bar alert was presented on the middle screen. Although reaction time was faster in general to the status bar as compared to the flashing border, this difference was not signficant when the alerts were presented on the left screen. Nevertheless, regardless of alert type participants reaction times were slowest to alerts presented on the left screen.

Table 5. Pair-wise comparisons of Alert type and Location.

Pair-wise Comparisons Logged Reaction Time		Means	t-values	df	Sig. (2-tailed)
Pair 1	Left Status Bar – Left Flashing Border	2.9921 3.0135	-1.141	21	.266
Pair 2	Middle Status Bar – Middle Flashing Border	2.9315 2.9991	-3.560	21	.002*
Pair 3	Right Status Bar – Right Flashing Border	2.9481 3.0212	-4.688	21	.000*
Pair 4	All Status Bar – All Flashing Border	2.9018 2.9969	-6.814	21	.000*
Pair 5	Middle Status Bar – All Status Bar	2.9315 2.9018	1.902	21	.070
Pair 6	Right Status Bar – All Status Bar	2.9481 2.9018	2.985	21	.007*
Pair 7	Left Status Bar – All Status Bar	2.9921 2.9018	4.805	21	.000*

3.4 Contact Identification (Hostile/Neutral)

Tests of normality on the sampling distribution indicated that the contact identification accuracy data had a mesokurtic distribution. Shapiro-Wilkes test of normality did not produce significant results for this data.

The repeated measure ANOVA for the number of hostile contacts identified indicate that there was a significant main effect of block, $F(1, 6) = 7.64$, $p < .05$, $MSE = 112.41$, $\eta_\rho^2 = .56$, suggesting that participants were improving across time (see Figure 10). No significant interaction or main effect of contact type or alert type was found. Follow on pair-wise comparisons using least significant differences.corrections indicate that participants' performance for hostile contact identification was significantly better in block 8 compared to all other blocks (see Table 6). The repeated measure ANOVA for the number of neutral contacts identified did not provide a significant block x alert type x contact type interaction. No significant main effects of block, alert type or contact type were found. The data suggests that a learning asymptote was not achieved within 8 blocks, so any future research should include additional blocks to the experimental session. Conducting a follow-on pilot study could determine how many blocks would be required to reach a learning asymptote if this is required.

Table 6. Comparison of Mean Hostile Contacts Identified x Block

Block	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	12.29	1.02	9.80	14.77
2	11.50	0.96	9.16	13.84
3	13.36	0.88	11.21	15.50
4	12.64	0.84	10.60	14.69
5	13.36	1.04	10.80	15.91
6	14.21	0.82	12.20	16.23
7	14.79	1.14	11.99	17.58
8	21.00	1.90	16.35	25.65

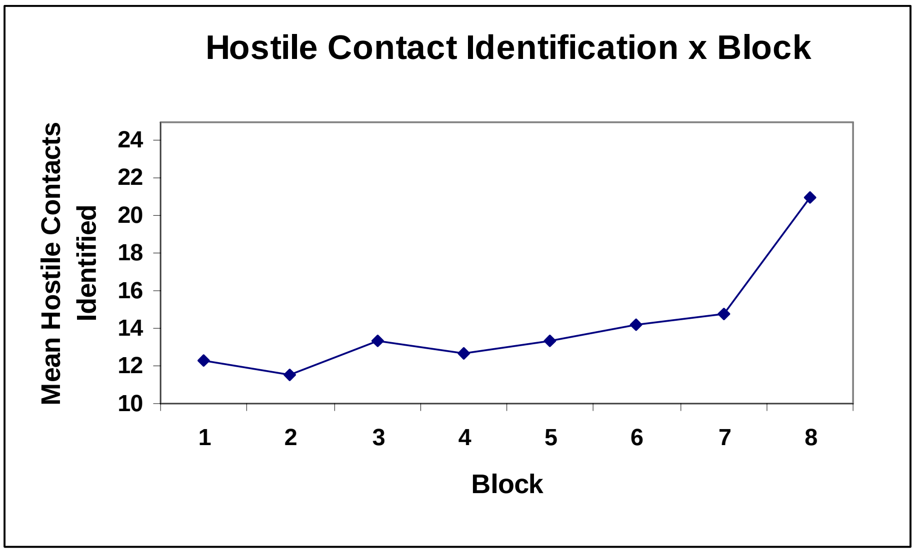

Figure 10. Mean Hostile Targets Identified by Block

4. Discussion and Recommendations for Future Experiments

The pupose of the current study was to investigate how a high intensity task using multiple displays impacts the detection of visual alerts. This study has provided evidence that the use of visual alerts in a high intensity environment, like those found in the Halifax Class Frigate operations room, may prove to be beneficial when the auditory modality is overloaded. The purpose of the current study was to investigate how a high intensity task spread across multiple displays impacts the detection of visual alerts. The results of this study clearly indicate a preference for a status bar when compared to a flashing border. Future experiments are recommended following the current results and these will also be discussed in terms of attention tunnelling and visual dominance.

One of the main findings from this study was that the status bar resulted in a significantly quicker response when compared to the flashing border alert. In this study the status bar alert was located on the top left hand side of the screen (see Figure 6) across all conditions. One problem with presenting the status bar on the top-left corner of the screen is that when the status bar is presented on the left and right displays, the status bar was not equidistant from the centre display. Therefore it is recommended that the location of the status bar alert should be investigated further in order to determine whether the quicker response is dependent on the location in which it is presented. For example a further study could compare the response times to a status bar presented on the top left, top right, top middle, bottom middle, left middle, and right middle screen locations.

Although it is not empirically known why the flashing border resulted in less attention, it is suspected that it may be poorly reacted to because it does in fact flash. To reiterate, one of the differences between the two alerts investigated was that the status bar was presented statically (no flashing) whereas the flashing border flashed on and off. This may have resulted in the flashing border having less “on screen” time. That is, it may be more likely that participants missed attending to the flashing border because they were glancing between screens and down towards the keyboard. Future research might explore this by comparing a status bar that flashes to the currently used solid status bar.

In complex environments attention to alerts or warnings usually needs to be followed by an understanding of the number presented, their priorities, importance, identification and localizability (Edworthy and Hellier, 2000). To provide more ecologically valid results it is recommended that the tasks and paradigm used in future studies may be more ecologically sound. For example, there may be situations in which visual and auditory signals are given together rather than as alternatives to each other in alerting human operators alongside a cluttered display. For this type of setup, signals of the auditory and visual modalities may be provided separately or simultaneously, synchronously or asynchronously to operators. For combined display of visual and auditory signals, the interactive effects are not yet known and there are no useful research results or practical ergonomic guidance available for use by industrial designers to date (Chan & Chan, 2006). Additional ecologically valid paradigms might include investigating various alert types and locations on multiple operators working in a collaborative environment (Burns, Greenley, Roth, Barone & Brooks, 2002), cluttered and dynamic displays (Boot, Kramer, Becic, Wiegmann, & Kubose, 2006)

Although there are many recommendations provided for future work it is argued that a complete user needs analysis should be conducted on the current Halifax Class Frigate operations room warning system. Because there are a number of possibilities why the alert system is intentionally deactivated: the majority of alerts are auditory, burdening an already overtaxed modality; all operators receive all alerts, many are of no concern for an individual operator; alerts are not informative, they are single tone; there is no alert hierarchy; the presentation of auditory alerts is almost constant, a user needs analysis may provide some insight into what type of paradigm implemented in following studies would provide the most useful results.

5. References

1. Boot, W.R., Kramer, A.F., Becic, E., Wiegmann, D.A., & Kubose, T. (2006). Detecting transient changes in dynamic displays: The more you look, the less you see. Human Factors 48, 759-773.

2. Burns, C., Greenley, M., Roth, E., Barone, A., Brooks, J. (2002). Literature Survey for Collaborative Displays. Department of National Defence, Defence Research and Development Canada – Toronto, ON. Canada.

3. Chan, H.S.A. & Chan, K.W.L (2006). Synchronous and asynchronous presentations of auditory and visual signals: Implications for control console design. *Applied Ergonomics*, 37, pp. 131–140.

4. Colavita, F. B., & Weisberg, D. (1979). A further investigation of visual dominance. Perception and Psychophysics, 25, 345-347.

5. Cooper, R. (1998). Visual Dominance and the Control of Action. Proceedings of the 20th Annual Conference of the Cognitive Science Society, pp. 250-255.

6. Czarnolewski, M. (1996, September). An empirical validation for the natural log transformation of reaction time. Paper presented at the annual meeting of the Human Factors and Ergonomics Society, Philadelphia, PA.

7. Donmez, B., Boyle, L. N., & Lee, J. D. (2006). Drivers' attitudes toward imperfect distraction mitigation strategies. Transportation Research Part F: *Traffic Psychology*, 9(6), 387-398.

8. Edworthy, J. & Hellier, E .J. (2000) Auditory warnings in noisy environments. Noise & Health, 6, 27-39.

9. Pigeau, R. (1992). Command Group’s Guide to stress compensation for human subjects. Unpublished DRDC Document, DRDC Toronto.

10. Posner, M. I., Nissen, M. J., & Klein, R. M. (1976). Visual dominance: An information-processing account of its origins and significance. Psychological Review, 83, 157-171.

11. Salvendy, G., (1997) Ed. Chapter 7: Evaluation. In Handbook of Human Factors and Ergonomics. New York: Wiley, second edition, pp. 1449-1633.

12. Wickens, C. D. (2005). Attentional tunneling and task management. *Proceedings of the 13th International Symposium on Aviation Psychology*, Dayton, OH.

Annexes

Annex A: Recruitment Poster

<u>Evaluating visual alerts in the maritime domain</u>

PARTICIPANTS:
Males and females, between the ages of 18 and 60 years, with normal or corrected to normal vision.

OBJECTIVES:
The study is designed to investigate how a high intensity task impacts detection of visual alerts, especially when the task requires monitoring more than one display. The experimental design includes two types of alerts (flashing border/ status bar) and three displays. The task involves classifying and reporting contacts on a tactical display as hostile or neutral while also detecting and responding to visual alerts presented on one or all of the displays.

PROCEDURE:
Participants in this experiment are seated at a three-monitor workstation and instructed that their task is to protect their ship from attack by vessels in the surrounding waters. The position of all vessels is shown on a tactical display and information as to whether other vessels are hostile or neutral is provided on a status display to assist the participant in making an accurate decision. During the task visual alerts appear on one of the displays. Participants use the keyboard to respond to the alert. The session will last approximately 1 hour.

RISKS:
Participants will be required to remain vigilant and alert throughout session. No unusual risks are anticipated, however, other than possible eyestrain and fatigue.

BENEFITS:
Participants may benefit from the experience by gaining knowledge of the maritime environment and in receiving exposure to the defence research environment.

WHEN:
During normal working hours in December 2007 – February 2008

WHERE:
DRDC Atlantic, 9 Grove Street, Dartmouth, Nova Scotia, B2Y 3Z7

COMPENSATION:
Participants will be compensated according to DRDC guidelines

For more information, all interested volunteers should contact:
Jacqui Crebolder @ 902 426-3100 x296/jacqui.crebolder@drdc-rddc.gc.ca
CAE representative TBD

This page intentionally left blank.

Annex B: Voluntary consent form for human subject participation

Research Project Title: Evaluating visual alerts in the maritime domain

Principal Investigator: Dr. Jacquelyn Crebolder
Joe Armstrong - CAE Professional Services;
Shelley Roberts - CAE Professional Services;
Tara Foster-Hunt - CAE Professional Services

I, _____________________ (name) of _________________________________ (address and phone number) hereby volunteer to participate as a subject in the study, "____" (Protocol #L623). I have read the information package on the research protocol, and have had the opportunity to ask questions of the Investigator(s). All of my questions concerning this study have been fully answered to my satisfaction. However, I may obtain additional information about the research project and have any questions about this study answered by contacting Dr. Jacqui Crebolder (902) 426-3100 x296.

I have been told that I will be asked to participate in one session totaling approximately one and one half hours in duration.
The task is a computer-based task that consists of monitoring a central display for contacts, gathering information on those contacts from a second display, and reporting the nature of those contacts on a third display.

I have been told that the principal risks of the research protocol are: possible minor eyestrain and fatigue. Also, I acknowledge that my participation in this study, or indeed any research, may involve risks that are currently unforeseen by DRDC Atlantic.

For Canadian Forces (CF) members only: I understand that I am considered to be on duty for disciplinary, administrative and Pension Act purposes during my participation in this experiment and I understand that in the unlikely event that my participation in this study results in a medical condition rendering me unfit for service, I may be released from the CF and my military benefits apply. This duty status has no effect on my right to withdraw from the experiment at any time I wish and I understand that no action will be taken against me for exercising this right.

I have been advised that the experimental data concerning me will be treated as confidential ('Protected B' IAW CF Security Requirements), and not revealed to anyone other than the DRDC Atlantic Investigator(s) or external investigators from the sponsoring agency without my consent except as data unidentified as to source. Also, I understand that my name will not be identified or attached in any manner to any publication arising from this study. Moreover, should it be required, I agree to allow the experimental data to be reviewed by an internal or external audit committee with the understanding that any summary information resulting from such a review will not identify me personally.

I understand that I am free to refuse to participate and may withdraw my consent without prejudice or hard feelings at any time. Should I withdraw my consent, my participation as a subject will cease immediately, unless the Investigator(s) determine that such action would be dangerous or impossible (in which case my participation will cease as soon as it is safe to do so). I also understand that the Investigator(s), their designate, or the physician(s) responsible for the research project may terminate my participation at any time, regardless of my wishes.

I have been informed that the research findings resulting from my participation in this research project may be used for commercialization purposes.

I understand that for my participation in this research project, I am entitled to remuneration in the form of a stress allowance in the amount of $15.68 (plus $15.00 for travel if I am coming from outside DRDC Atlantic) for completing one session.
Stress remuneration is taxable. T4A slips are issued only for amounts in excess of $500.00 paid during a year.

Secondary Use of Data: I consent/do not consent (delete as appropriate) to the use of this study's experimental data involving me in unidentified form in future related studies provided review and approval have been given by DRDC HREC.

Volunteer's Signature: _______________________________ Date: __________________

I have informed the Principal Investigator that I am currently a subject in the following other DRDC Atlantic research project(s): ____ (cite Protocol Number(s) and associated Principal Investigator(s)), and that I am participating as a subject in the following research project(s) at institutions other than DRDC Atlantic: ____ (cite name(s) of institution(s))

I understand that by signing this consent form I have not waived any legal rights I may have as a result of any harm to me occasioned by my participation in this research project beyond all risks I have assumed.

Volunteer's Name ________________________ Signature:
Date: _________________

Name of Witness to Signature:
Signature: ____ Date:

Section Head/Commanding Officer's Signature (see Notes below)_____________________
CO's Unit: _____________________________

Principal Investigator: _________________________ Signature:
Date: _______________

Notes:
For other military personnel: All other military personnel must obtain their Commanding Officer's signature designating approval to participate in this research project.
For civilian personnel at DRDC Atlantic: Signature of Section Head is required designating that volunteer subject is considered to be at work and that approval has been given to participate in this research project.

FOR SUBJECT ENQUIRY IF REQUIRED:

Should I have any questions or concern regarding this project before, during, or after participation, I understand that I am encouraged to contact Defence R&D Canada – Atlantic (DRDC Atlantic), 9 Grove Street, Dartmouth, Nova Scotia, B2Y 3Z7. This contact can be made by surface mail at this address or in person, by phone or e-mail, to any of the DRDC Atlantic numbers and addresses listed below:

Principle Investigator or Principal DRDC Atlantic Investigator:
Dr. Jacquelyn Crebolder, (902) 426-3100 x296, jacqui.crebolder@drdc-rddc.gc.ca

Or to the Chair of the DRDC Human Research Ethics Committee (HREC)
Dr. Jack Landolt, (416) 635-2120, jack.landolt@drdc-rddc.gc.ca

I understand that I will be given a copy of this consent form so that I may contact any of the above-mentioned individuals at some time in the future should that be required.

This page intentionally left blank

Annex C: Participant Instructions and Scenario

Prior to reading the on screen instructions participants were read the following:

> "You are a control operator on a Navy ship. Your primary responsibility is to attend and respond to visual alerts that appear on your displays. Your secondary task is to determine whether targets approaching your ownship are neutral or hostile.
>
> I will have you read the first screen for instruction and they we will continue…"

Participants then read the following on the middle screen:

> "There are two types of visual alerts that will appear on your displays; a red bar that will always appear on the left top area of the display and a red border that surrounds the periphery of your screen. Only one type of display will appear at a time. The displays may appear on the left display, middle display, right display or all three at once.
>
> When you hit the space bar the alert will disappear immediately. Alerts, if not responded to will disappear after a short duration.
>
> Just to remind you – it is your primary task to respond to alerts.
>
> Any target, whether it is neutral or hostile will destroy your ownship if it reaches the centre of the screen. You do not have to move the cursor inside the textbox to enter your answer – you may just type. However, you will need to move the cursor over the enter button on the right screen and click enter with the mouse. You are not able to enter your answer using the "enter button" on the keyboard.
>
> To summarize: Responding to alerts is your primary task, your secondary task is to identify whether approaching targets are neutral or hostile.
>
> Do you have any questions?"

This page intentionally left blank.

Distribution list

Document No: DRDC Atlantic CR 2008-057

LIST PART 1: Internal Distribution by Centre:

DRDC Atlantic Library (5)
DRDC Atlantic Scientific Authority (2)
Bruce Chalmers (1)

TOTAL LIST PART 1 - 8

LIST PART 2: External Distribution by DRDKIM

Sharon Abel (1)
Ann Nakashima (1)
DRDC Toronto
PO Box 2000
Toronto, Ontario
M3M 3B9

Denis Gendron (1)
LCdr Jacques Olivier (1)
Capt Alexander Natale (1)
Philippe Nitchuk (1)
ADM(MAT)
DGMPD (L&S)
PMO CSC
105 Hotel de Ville
National Defence
101 Colonel By Drive
Ottawa, Ontario
K1A 0K2

DRDKIM (1)

TOTAL LIST PART 2 - 7

TOTAL COPIES REQUIRED - 15

This page intentionally left blank.

DOCUMENT CONTROL DATA
(Security classification of the title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATOR (The name and address of the organization preparing the document, Organizations for whom the document was prepared, e.g. Centre sponsoring a contractor's document, or tasking agency, are entered in section 8.)	2. SECURITY CLASSIFICATION (Overall security classification of the document including special warning terms if applicable.)
Publishing: DRDC Atlantic Performing: CAE Professional Services, 1145 Innovative Dr., Kanata, Ontario, K2K 3G7 Monitoring: Contracting:	UNCLASSIFIED

3. TITLE (The complete document title as indicated on the title page. Its classification is indicated by the appropriate abbreviation (S, C, R, or U) in parenthesis at the end of the title)

Evaluation of Visual Alerts in the Maritime Domain (U)
Évaluation des alertes visuelles dans le domaine maritime

4. AUTHORS (First name, middle initial and last name. If military, show rank, e.g. Maj. John E. Doe.)

S. Roberts; T. Foster−Hunt

5. DATE OF PUBLICATION (Month and year of publication of document.)	6a NO. OF PAGES (Total containing information, including Annexes, Appendices, etc.)	6b. NO. OF REFS (Total cited in document.)
September 2008	44	12

7. DESCRIPTIVE NOTES (The category of the document, e.g. technical document, technical note or memorandum. If appropriate, enter the type of document, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)

Contract Report

8. SPONSORING ACTIVITY (The names of the department project office or laboratory sponsoring the research and development − include address.)

Sponsoring:
Tasking: DRDC Atlantic

9a. PROJECT OR GRANT NO. (If appropriate, the applicable research and development project or grant under which the document was written. Please specify whether project or grant.)	9b. CONTRACT NO. (If appropriate, the applicable number under which the document was written.)
	W7707−07−8043

10a. ORIGINATOR'S DOCUMENT NUMBER (The official document number by which the document is identified by the originating activity. This number must be unique to this document)	10b. OTHER DOCUMENT NO(s). (Any other numbers under which may be assigned this document either by the originator or by the sponsor.)
DRDC Atlantic CR 2008−057	

11. DOCUMENT AVAILABILITY (Any limitations on the dissemination of the document, other than those imposed by security classification.)

Unlimited distribution

12. DOCUMENT ANNOUNCEMENT (Any limitation to the bibliographic announcement of this document. This will normally correspond to the Document Availability (11), However, when further distribution (beyond the audience specified in (11) is possible, a wider announcement audience may be selected.))

Unlimited announcement

DOCUMENT CONTROL DATA
(Security classification of the title, body of abstract and indexing annotation must be entered when the overall document is classified)

13. ABSTRACT (A brief and factual summary of the document. It may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall begin with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (S), (C), (R), or (U). It is not necessary to include here abstracts in both official languages unless the text is bilingual.)

(U) The current study was designed to explore alternative methods of enhancing the manner in which operators are alerted in the Halifax Class Frigate operations room. As the auditory modality is overloaded in the current alerting system, one method of potentially reducing perceptual overload is to replace auditory alerts with alerts presented in the visual domain. The purpose of the current study was to investigate how a high intensity task spread across multiple displays impacts the detection of visual alerts. The experimental design included two types of alerts (flashing border/status bar) presented independently on the left, right, or centre display or on all three displays. Participants were required to complete two tasks: 1. Classify and report contacts appearing on the centre display as hostile or neutral, and 2. Detect and respond to visual alerts. Reaction time to alerts and accuracy of the identification of alerts and contacts were examined. In general, reaction time to status bar alerts was faster than to border alerts, although no significant difference was observed when the alerts appeared on the left display. Responding to the status bar alert when it was presented on all three displays at once compared to all other alert configurations was found to be fastest. No significant difference in accuracy was found. Results in this study suggest that the type and location of visual alerts has a significant impact on reaction time but no impact on accuracy. Further investigation of the interaction between auditory and visual alerts and their impact on high intensity tasks is highly recommended for future work.

(U) La présente étude a été élaborée pour explorer des méthodes de rechange permettant d’améliorer la façon avec laquelle les opérateurs sont alertés dans le PC opérations des frégates de classe Halifax. Comme le mode audible est surchargé dans le système d’alerte actuel, une des méthodes permettant la diminution possible de la surcharge au niveau de la perception consiste à remplacer les alertes sonores par des alertes visuelles. Le but de la présente étude est de faire enquête sur la façon dont une tâche à haute intensité répartie sur plusieurs écrans d’affichage a un impact sur la détection d’alertes visuelles. La conception expérimentale comprenait deux types d’alertes (limite clignotante/barre d’état) présentés indépendamment sur l’écran de gauche, de droite ou du centre, ou sur les trois écrans. Les participants devaient effectuer deux tâches : 1. classer et communiquer les contacts apparaissant sur l’écran du centre comme étant hostiles ou neutres et 2. détecter les alertes visuelles et réagir à celles ci. Le temps de réaction aux alertes et la précision de l’identification des alertes et des contacts ont été examinés. En général, le temps de réaction aux alertes de barre d’état a été plus rapide que le temps de réaction aux limites clignotantes bien qu’aucune différence importante n’a été observée lorsque les alertes se sont affichées sur l’écran de gauche. La réponse à l’alerte de la barre d’état lorsque celle ci s’est affichée sur les trois écrans en même s’est avérée plus rapide que toutes les autres configurations d’alertes. Aucune différence importante en matière de précision n’a été remarquée. Les résultats de la présente étude suggèrent que le type et l’emplacement des alertes visuelles ont un impact important sur le temps de réaction, mais qu’ils n’en ont aucun sur la précision. Il est fortement recommandé d’effectuer dorénavant une enquête plus approfondie sur l’interaction entre les alertes sonores et les alertes visuelles et sur leur impact sur les tâches de haute intensité.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (Technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

(U)

Defence R&D Canada

Canada's leader in defence
and National Security
Science and Technology

R & D pour la défense Canada

Chef de file au Canada en matière
de science et de technologie pour
la défense et la sécurité nationale

DEFENCE DÉFENSE

www.drdc-rddc.gc.ca